Antenna characteristics for vehicle-to-vehicle communications

Reliable vehicle-to-vehicle (V2V) communications is critical to an effective intelligent transportation system, and selecting reliable antennas is key. When choosing an antenna, gain, beamwidth and efficiency are important, as is the potential for ‘shadowing’, which arises when multiple antenna elements are combined in the same antenna housing.

Wireless systems involved in vehicle telematics have become increasingly complex. A simple DSRC network at 5.9 GHz may be used in conjunction with cellular, wi-fi, GPS or GLONASS. Some trials may require multiple streams for MIMO (multiple-input, multiple-output) coverage.

As the number of systems increases, there is a growing desire to combine some of these antennas into a consolidated package. Effective design work can ensure optimum performance for each antenna element and minimize interaction among the elements.

The only way to truly gauge the shadowing effects is to carefully study the antenna’s azimuth pattern, which should show a near-round pattern without any nulls greater than 3dB.

Nothing gained

Higher gain antennas can transmit signals over longer distances, but V2V communications will take place close together, with the most critical communications within 100m. Lower-gain antennas have a broader hemispherical coverage than higher-gain antennas, which exhibit wider but flatter coverage. For communications in hilly terrain or among vehicles of very different heights, such as between a bus and a sports car, the hemispherical coverage will be more effective.

Need to know

Criteria to consider when evaluating V2V antennas:

- Antennas producing nulls greater than 3dB indicate possible shadowing
- Higher gain antennas have wider, but flatter coverage. Lower gain creates broader hemispherical coverage – better for communicating between objects at different heights
- Obstacles on the vehicle such as roof racks, car trims, or other antennas, may cause shadowing or pattern interference

Shadowing can be created by the environment in which the antenna is mounted or by the antenna itself. For example, antennas mounted on the trunk of a vehicle will find their forward-facing signals blocked by the car itself, but the metal around the installation setting will also skew their radiation pattern. Many DSRC antennas are therefore best positioned on the roof of the vehicle, where there is better line-of-sight for the radio frequency (RF) signal.

Importance of design

Shadowing can also be caused by antenna design. Positioning of elements within the antenna can create undesirable trade-offs. Some may block or redirect the signal of a neighboring element, creating an uneven radiation pattern.

Shadowing can be detected by looking at the radiation pattern. Testing the antenna on a standard ground plane, measured in free space, will enable evaluation, independent of any impact from the vehicle setting. Nulls in the omnidirectional radiation pattern indicate that shadowing is occurring within the antenna itself. Non-circular patterns with nulls greater than 3dB will reduce V2V dependability.

Shadowing can occur when antenna elements are positioned on different physical planes within the antenna and can be eliminated by redesigning the board positions. Critical elements essential for collision avoidance and other safety-oriented communications, in this case the DSRC elements, should be located where they are not shadowed by other antenna elements. When ideally designed and positioned, the radiation pattern of these elements should be balanced and even in the horizontal plane. Any nulls in the radiation pattern should not exceed 3dB variation.

Antenna gain and VSWR (Voltage Standing Wave Ratio) performance are important measures for evaluating antennas. Checking for the impact of shadowing on the radiation pattern is crucial when selecting an antenna.

Above: Mobile Mark’s V2V antenna for MIMO DSRC and GPS/Glonass is designed to minimize DSRC shadowing